Kalpa Publications in Civil Engineering
Volume 1, 2017, Pages 150–156
ICRISET2017. International Conference on Research and Innovations in Science, Engineering &Technology. Selected papers in Civil Engineering

# Performance of Seashell Powder on Sub-grade Soil Stabilization

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**Abstract**

In India, increase in population coupled with heavy laden loads of vehicles conveying heavier stresses concentrates especially on roads running in clayey soil zones which create significant problems for pavements and hence need to be stabilized. Insecure soils make huge issues for asphalts and henceforth should be settled. In this study, at first the examination of normal soil is done to assess the physical and engineering properties as indicated by Indian Standard (1498 – 1970) by coordinating exploration focus tests and to evaluate the adjustment in properties by the utilizing sea shell powder as a part of dose of 12%, 15% and 18% as stabilizers to be used as a part of the asphalt configuration for the economy. Understanding the progressions in sub-grade quality, the correct outline systems of the asphalt layers based upon the sub grade quality can be worked out utilizing IRC code and comparative saving cost per km.

Key words: Soil Stabilization, Clay soil, Seashell powder, OMC-MDD, UCS, CBR.

## 1 Introduction

Roads going through extensive soil areas are subjected to serious pain bringing about poor execution and expanded upkeep cost. India is faced with saving and redesigning the pavement system, these require the enthusiasm of utilizing waste material for improving the security of soils. Expansive soils cover huge regions in a few nations of the world and in India too. These soils experience volumetric changes with the expansion in dampness content because of the presence of the mineral montmorillonite. Along these lines, in this review, a basic stride is being taken to finish financial usage of waste materials utilizing sea shell powder by trying to keep the wastage of soil material by enhancing the properties as per requirements of pavement design from its arranged use.

**Aim:** To stabilize the locally available sub-grade soil by using seashell powder.

**Objectives:**

- To study the basic index properties of the soil before and after addition of the Seashell Powder additive in suitable dosages.

C.D. Modhera, G.J. Joshi, D. Soni, I.N. Patel, A.K. Verma, L.B. Zala, S.D. Dhiman, D.R. Bhatt, J.M. Rathod, B.C. Goradiya, M.S. Holia and D.K. Patel (eds.), ICRISET2017 (Kalpa Publications in Civil Engineering, vol. 1), pp. 150–156

- To carry out a study of the CBR values and to design the flexible pavement thickness using the optimum value of CBR.
- To carry out cost saving analysis of the natural material without compromising the quality of work and material.

Mohan Chand (March 2016)[4] had found that the unconfined compressive strength of the ordinary soil increases by adding to it sea shell powder and comes out to be 256 KN/m$^2$and increased by 16% with the addition of seashell powder, that is 314 KN/m$^2$.So there is a 58% of the increase in strength of soil at 16% addition of seashell powder.

K. Mounika (Nov 2014)[5] uncovered that the CBR value increments by including the sea shell powder as an admixture at an extent of 5% to 45%. It achieves a most extreme CBR estimation of 7.8% at 20%, concerning original soil without including the admixture accomplishes an estimation of 1.0%.

Maheshwari G. Bisanal (July 2015)[17] had described that black cotton soil has a large tendency to swell and shrink with respect to variation in moisture content, thus causing serious problem to the structures built on that. The most common methods for stabilizing black cotton soil are using lime, cement, kiln dust, iron slag, cattle waste ash, industrial wastes and sea shell powder which cause problems in disposal and create environmental pollution

Karthika Prasad (June 2016)[1] had found that the increase in unconfined compressive strength of kuttanad clay, by testing it after placing the sample for a curing period of 0,4,7 days. Also, the Geotechnical properties and volumetric shrinkage strain of Kuttanad clay were tested in this study. The eggshell powder can be used to considerably improve the strength of soil. The result of the unconfined compressive test with eggshell as a stabilizing agent at varying percentage (10%, 15%, 20%) after 0, 4, 7 days each showed that the strength increases at 15% after 7 days curing which is the optimum value and reduces by 20%. For each value of optimum moisture content determined from the standard proctor test, a sample was prepared using the same proctor mold after compacting each layer, after which it was extruded out of this mold and its dimensions were calculated. The change in the dimensions was noted after a period of 4, 7 days. Minimum volume change was observed at 15%, which is found to be the optimum percentage.

P. P Nagrale (Jan 2016)[18] had found that weak soil has a low California bearing ratio (CBR) which will lead to more layer thicknesses of the pavement section. Two types of soil (Soil A and Soil B) having CBR of 1.45 and 4.67 and three types of stabilizers that are hydrated lime, class F fly ash and polypropylene fiber (aspect ratio of 100) were selected for the laboratory investigation. An experimental program consisting of Atterberg’s limit, compaction, CBR and UCS tests were carried out. Percentage of lime varied from 1.5, 3.0, 4.5 and 6 %, for fly ash stabilization, it was 5, 10, 15 and 20 %, whereas the percentage of fiber varied from 0.25, 0.50, 0.75 and 1 %. Results of laboratory investigation revealed that 4.5 % lime, 10 % fly ash and 0.5 % of fire were optimum for the enhancement of strength characteristics of sub-grade soil stabilization.

Arathy V. B. (Feb 2015)[3] had described that coconut shells are opulently available and is devoted to assessing its suitability as a stabilizing agent in powder form in the field of soil improvement. Different tests were conducted on soil with varying percentage of coconut shell powder (1%, 2%, 3% and 4%).

# 2 Materials

The materials which are to be used in this study as follows:

A. Clay Soil: The Soil is collected from the Valsad city near NH-48 at 2 m depth. The experiments are conducted in NKPC-Geotechnical laboratory, Valsad, Gujarat. The soil used is the extracted waste soil, which on the visual test and by laboratory test known to be clay soil. The soil is intermediate plastic clayey soil, i.e. CI soil. Test according to Indian Standards are performed on the soil to check the properties of untreated and treated the soil with stabilizer.Properties of clay soil are shown in table 1.

| Sr. No. | Property | Value |
|---|---|---|
| 1 | Specific Gravity | 2.4 |
| 2 | Liquid Limit | 41.75% |
| 3 | Plastic Limit | 25.28% |
| 4 | Plasticity Index | 16.67% |
| 5 | Free Swell Index | 60% |
| 6 | Optimum Moisture Content | 17.70% |
| 7 | Maximum Dry Density | 1.7360 g/cc |
| 8 | Unconfined Compressive Strength | 51.66 KPa |
| 9 | California Bearing Ratio | 2.38% |

**Table 1** Properties of clay soil

B. Seashell Powder: The seashell is a waste material obtained near the seashore area is made in powdery form (figure 1) as per the code for the work. Seashell containing the 90% of calcium carbonate, remaining 10% it contains dust and impurities.

**Figure 1** Seashell Powder

# 3 Experimental Outcome

A. Sample Preparation and tests

The soil sample is collected from the site and dried out in direct sunlight; the clods are busted to get the uniform sample. The busted wooden material, small aggregates, organic matters are shifted carefully from soil samples. The sample is kept in the oven for drying to use in a test at temperature $150^0$C for 24 hours. Basic properties of soil are determined. The weight of soil sample taken for a test is replaced by a different proportion of the weight of seashell powder in varying amounts of (12%, 15%, and 18%). The soil stabilized with seashell powder and the strength parameters like OMC-MDD, CBR and UCC were determined. By getting out on each result of all these blends the comparison of the best suitable additive mix will be carried out.

B. Results of OMC and MDD for Clay soil stabilized with seashell powder

The OMC and MDD of the soil samples for sundry percentages of seashell powder (12%, 15%, and 18%) were determined by performing the Standard proctor test. The dry density was resolute and plotted against the corresponding water content to ascertain OMC and MDD. The values of percentage of seashell powder are tabulated in table 2.

| % Replacement | Clay Soil + % Seashell Powder | |
|---|---|---|
| | OMC (%) | MDD (g/cc) |
| 0 | 17.70 | 1.7360 |
| 12 | 17.54 | 1.7550 |
| 15 | 16.65 | 1.7952 |
| 18 | 16.13 | 1.7713 |

**Table 2** OMC-MDD of the samples

C. Results of California Bearing Ratio (CBR) test for clay soil stabilized with seashell powder

The CBR test is carried out as per the IS code 2720 part 16, 1987 on the soil containing 12%, 15% and 18% of seashell powder (fig 2) and the outcome is as shown in table 3.

| % Replacement | Clay Soil + % Seashell Powder |
|---|---|
| 12 | 5.8 |
| 15 | 6.89 |
| 18 | 6.13 |

**Table 3** CBR for Different dosages of Seashell Powder

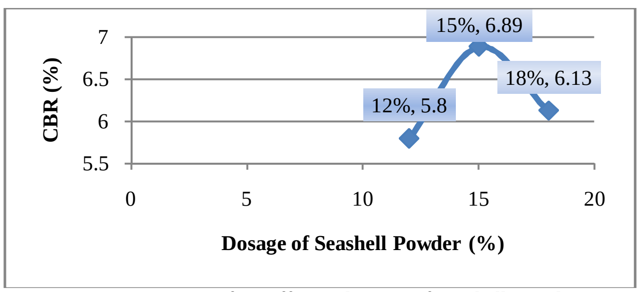


**Figure 2** CBR for Different dosages of Seashell Powder

D. Results of Unconfined Compressive Strength (UCS) test of Clay soil stabilized with seashell powder

The samples were tested as per the IS code 2720 part 10 1991 by using seashell powder integrated into the proportions 12%, 15% and 18% of the soil. The significant increase is noted specially at 15% replacement of soil with additive coming out to be 71.27 KPa (fig. 3). The results were obtained from the test as shown in table 4.

| % Replacement | Clay Soil + % Seashell Powder (KPa) |
|---|---|
| 12 | 64.52 |
| 15 | 71.27 |
| 18 | 68.68 |

**Table 4** UCS for Different dosages of Seashell Powder

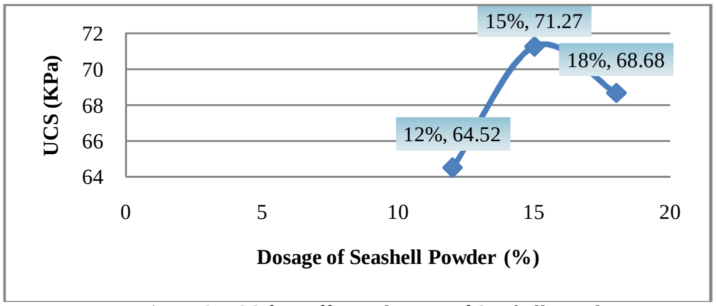


**Figure 3** UCS for Different dosages of Seashell Powder

E. Thickness Design of Flexible Pavement as per IRC: 37 – 2012

**Data:**

- National Highway (6 Lane)
- Design Traffic (A) = 1000 CVPD
- Lane Distribution Factor (D) = 60 percent (Three Lane Dual Carriageway Road)
- Vehicle Damage Factor (F) = 4.5 (Plain Terrain)
- Design Life (n) = 15 years
- Annual Growth Rate (r) = 7.5 percent (Assumed)
- Width = 10.5 + 10.5 m (Considering only single side, i.e. 10.5 m)
- Design Soak CBR = 2.38% (obtained)

**Design Calculations:**

Cumulative no. of standard axle load,

$$N = \frac{365 \text{ x } [(1 + r)^n - 1]}{r} \text{ x A x D x F}$$

$$N = \frac{365 \text{ x } [(1 + 0.075)^{15} - 1]}{0.075} \text{ x } 1000 \text{ x } 0.60 \text{ x } 4.5$$

$$N = 25.74 \text{ msa} = 26 \text{ msa}$$

Now, for 2% CBR and 26 msa traffic, thickness design is calculated as per IRC: 37 – 2012, pg.26. After interpretation of 26 msa traffic Pavement composition is shown in fig. 4.

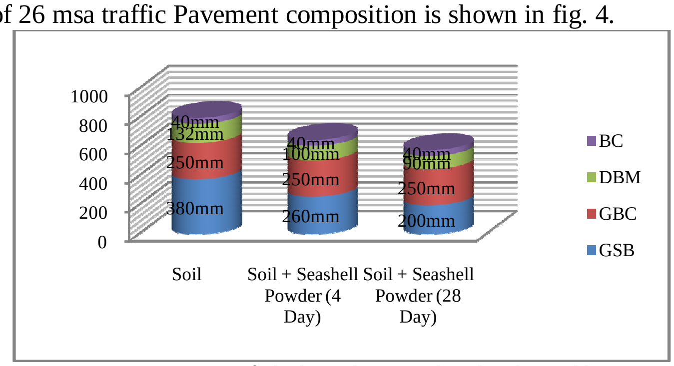


**Figure 4** Comparison of Thickness layers with and without additives

F. Construction Cost

| Sr. No. | Materials | Cost (Rs.) |
|---|---|---|
| 1 | Clay Soil | 21,258,573 |
| 2 | Clay Soil + Seashell Powder (15%) | 17,518,305 |

**Table 5** Summary of Cost Analysis (1 km) for 10.5 m width of road

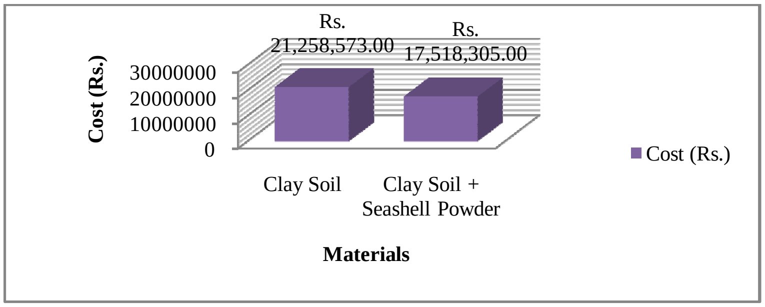


**Figure 5** Summary of Cost Analysis (1 km) for 10.5 m width of road

# 4 Conclusion

The key findings show that with the increase of sea shell powder, maximum dry density goes on increasing while optimum moisture goes on decreasing which is a good sign of soil as more dense and hard. The maximum, optimum moisture content of 16.65% is reached at 15% of sea shell powder. Up to this stage, the California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) is on the rising trend. The initial increase in the CBR is expected because of the gradual formation of cementitious compounds and this rise in trend is noted up to 15% addition of seashell powder after which decrease is noted which is due to lower moisture content and lower MDD. The increase in CBR of stabilized soil noted is 2.89 times that of ordinary soil. The UCS vale for soil with 15% additive is @ 14% more compared to ordinary soil. The cost of untreated soil per km comes out to be Rs. 21,258,573 while soil treated with 15% seashell powder per km comes out to be Rs. 17,518,305. Also, the cost reduces to Rs. 3,740,268 per km when treated with seashell powder (15%). The highway contractors and pavement designers can avail the usage of sea shell powder 15% with ordinary soil, as it is alluring and backings the supportable improvement in road development.

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